Numerical Transport Methods Syllabus

NUMERICAL METHODS
FOR
PARTICLE TRANSPORT CALCULATIONS

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SEMESTER I

1. Fundamental Concepts of Transport Theory
   (a) Phase Space
   (b) Phase-Space Density
   (c) Angular Flux and Intensity
   (d) Scalar Flux and Intensity
   (e) Current/Flux
   (f) Cross Section
   (g) Reaction Rate
   (h) Momentum Tranfer
   (i) Stopping power
2. Fundamental Forms of the Integro-Differential Transport Equation
   (a) The Boltzmann Equation for Neutral Particles
   (b) The Boltzmann-Fokker-Planck Equation for Charged-Particles
   (c) The Equations of Radiative Transfer
3. The Integral Form of the Neutral-Particle Transport Equation
4. Elementary Solutions of the Neutral-Particle Transport Equation
   (a) Vacuum and Pure Absorber Solutions
   (b) Fourier Transform and Case Solutions

5. Properties of the Boltzmann Scattering Operator
    (a) Eigenvalues
    (b) Eigenfunctions
    (c) Addition Theorem for the Spherical Harmonic Functions
6. Asymptotic Transport Approximations
    (a) The Neutron Diffusion Limit
    (b) The Thermal Radiation Diffusion Limit
    (c) The Fokker-Planck Continuous-Scattering Limit
    (d) The Fokker-Planck Continuous-Slowing-Down Limit
7. Numerical Solution of the Diffusion Equation
    (a) Finite Difference Methods
    (b) Finite-Element Methods
8. Hybrid Transport-Diffusion Methods
    (a) The First-Scattered Distributed Source Technique
    (b) The N'th-Scattered Distributed Source Technique
9. Angular Discretization Techniques for the Integro-Differential Transport Equation
    (a) The Spherical-Harmonics or P_n Method
    (b) The Discrete-Ordinates S_N Method
    (c) Finite-Element Methods
10. Asymptotic Behavior of Numerical Transport Schemes
    (a) Order of Convergence
    (b) Positivity
    (c) Diffusion-Limit Behavior
11. Spatial Discretization Schemes for the S_n Equations
    (a) Step Differencing
    (b) Diamond Differencing
    (c) Discontinuous Finite-Element Methods

12. Solution of the S_n Equations
    (a) The Source Iteration Method
    (b) Fourier Analysis of the Source Iteration Method
    (c) Diffusion-Synthetic Acceleration
    (d) Krylov Solution Techniques

SEMESTER II

1. S_n Discretization of the Spherical Geometry Transport Equation
2. Solution of the Spherical Geometry S_n Equations
3. Short-Characteristic/VEF Methods
4. Energy Discretization for the Transport Equation
    (a) The Classic Multigroup Method
    (b) The Multigroup/Galerkin Method
    (c) Discontinuous Finite-Element Treatment for the CSDA Operator
5. Time Discretization for the Transport Equation
    (a) Backward-Euler Differencing
    (b) Crank-Nicholson Differencing
    (c) Gear Methods
    (d) Discontinuous Finite-Element Methods
6. Solution of the Thermal Radiative Transfer Equations
    (a) Linearization of the Equations
    (b) Solution of the Linearized Equations via Source Iteration
    (c) Convergence Acceleration Techniques
7. Solution of the Boltzmann-Fokker-Planck Equation
    (a) Discretization of the Fokker-Planck Operators
    (b) Solution of the Equations via Source Iteration